MASTER

VIII

# ACCUMULATED TEMPERATURE IN ENGLAND AND WALES

Accumulated temperature is the integrated excess or deficiency of temperature, measured with reference to a datum value, over an extended period of time. For this note, 42°F. has been adopted as the basic temperature following the view that this value is the critical temperature above which the growth of vegetation in a European climate is initiated and maintained. Accumulated temperature is expressed in units of day-degrees Fahrenheit and is calculated thus: if on a given day the temperature is above 42°F. for n hours and the mean temperature during that period exceeds the datum value by m degrees, the accumulated temperature for the day above 42°F. is nm hour-degrees or nm/24 day-degrees. Since, however, continuous records of temperature were not available, the accumulated temperature was evaluated in accordance with the instructions and tables given in Meteorological Office Form 3300 "Tables for the Evaluation of Daily Values of Accumulated Temperature above and below 42°F. from Daily Values of Maximum and Minimum Temperatures".

In this analysis the accumulated temperature in day degrees, above and below 42°F. has been calculated for each month and season for 28 selected stations in England and Wales for the period 1931-1948. An index map of the stations is given in Fig. 1.

The average monthly and seasonal accumulated temperatures above and below 42°F. for each station are given in Tables I, II and III. From Table I it will be seen that on average the accumulated temperature above 42°F. is 400 day-degrees or more everywhere for each of the months June to September, except in Northern England and the Welsh Hills. In July and August the average exceeds 600 day degrees in many places, particularly in Eastern and Southern England, and reaches a maximum of 643 day degrees at Wisley in July. During January and February the average falls to 20-40 day degrees in the north and in the Welsh Hills, but increases generally southwestwards to over 100 near Penzance.

Considering the seasonal averages above 42°F. in Table III it will be seen that in Spring the averages mostly exceed 600 day-degrees, and more than 700 day-degrees are reached at Gulval (near Penzance), Wisley (Surrey), Cannington (Bridgwater) and Worcester. The distribution of the Spring total is generally speaking 1/2 in May, 1/3 in April and 1/6 in March. Comparing Autumn and Spring it is noticed that there is an excess of 150-300 day-degrees in Autumn on average, varying from 145 at Newton Rigg in Cumberland to 536 at Gulval. In summer the highest average is found in S.E. England, but in winter it is found in S.W. England.

Now consider the averages of accumulated temperature below 42°F. (Table II). During the months June to September the averages are very small, the highest being 11 day-degrees at Houghall in September. January has the greatest number of day degrees below 42°F. on average, varying from 50-100 in Cornwall and Caernarvon to about 200 in the East and North of England. The Spring averages (March to May totals) show that only in S.W. England and N. Wales are the averages below 100 day degrees. Elsewhere they range up to a maximum of 222 at Thetford (Norfolk). March supplies about 2/3 of the Spring total, and April about 1/4.

Figures 2 and 3 show the variations about the seasonal means of accumulated temperature above and below 42°F. at Gulval and Rothamsted.

During the period under consideration, (1931-48) it will be clearly seen from Fig. 2 that in the summers, even though the means of accumlated temperatures at Gulval and Rothamsted are very close, the range at Rothamsted is nearly 100 day-degrees more. In Spring only on one occasion did the total of day degrees at Gulval fall below the average at Rothamsted. In Autumn only twice were the lowest totals at Gulval less than the highest at Rothamsted, while in Winter the lowest total at Gulval was greater than the highest at Rothamsted.

Considering the totals of accumulated temperature below 42°F. (Fig. 3) it is clearly apparent that in each season the highest totals at Gulval were always less than the lowest at Rothamsted.

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Fig. 4 illustrates the fact that in any one region, the deviations from the long term mean in any one year are much the same for all stations in that region, despite the fact that the means themselves may differ.

It is interesting to compare Aberystwyth (452 feet) and Llety-evan-hen (950 feet) to illustrate the differences found with an increase in height. Both stations are satisfactorily exposed, and are within a few miles of each other.

Above 42°F.

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aberystwyth | 47 | 41 | 96 | 155 | 295 | 422 | 505 | 538 | 423 | 266 | 135 | 73 | 2996 |
| Llety-evan-hen | 28 | 24 | 68 | 119 | 248 | 371 | 450 | 483 | 362 | 210 | 94 | 42 | 2499 |
| Difference | 19 | 17 | 28 | 36 | 47 | 51 | 55 | 55 | 61 | 56 | 41 | 31 | 497 |

The total excess at Aberystwyth during the Summer (June-Aug.) and the Autumn (Sept.-Nov.) is almost the same, 161 against 158 day-degrees. Even during the Winter (Dec.-Feb.) the excess is 67 day-degrees.

Below 42°F.

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aberystwyth | 119 | 110 | 68 | 25 | 9 | 0 | 0 | 0 | 1 | 7 | 27 | 78 | 444 |
| Llety-evan-hen | 161 | 150 | 97 | 40 | 14 | 1 | 0 | 0 | 1 | 11 | 43 | 105 | 623 |
| Difference | 42 | 40 | 29 | 15 | 5 | 1 | 0 | 0 | 0 | 4 | 16 | 27 | 179 |

Considering this table, the deficiency at Aberystwyth in Spring is 49 day-degrees whereas in Autumn the deficiency is less than half of that viz. 20 day-degrees. The totals during the Winter show a deficiency of 109 day-degrees.

NOTE:-

Averages of accumulated temperature above and below 42°F. for each month and the year have been computed in M.O.3. for the period 1921-1950 using the statistical method due to H.C.S. Thom (M.W. Rev. 82, 1, 1954, and 82, 5, 1954). These computed averages are available in M.O.3. for the following stations:-

Lerwick
Wick
Fortrose
Stornoway
Aberdeen
Braemar
Leuchars
Edinburgh
Tiree
Renfrew
Colmonell
Eskdalemuir
Douglas
Cockle Park
Tynemouth
Durham
York
Spurn Head
Gorleston
Felixstowe
Cambridge
Rothamsted
Sheffield
Nottingham
Birmingham (Sparkhill)
Oxford
Ross-on-Wye
Kew
Wisley
Dungeness
Southampton
Ventnor
Marlborough
Porton
Keswick
Manchester (Whitworth Park)
Southport
Stonyhurst
Bidston
Holyhead
St. Ann's Head
Cardiff
Portland Bill
Shaftesbury
Cullompton
Plymouth
Scilly

December, 1955.

Meteorological Office,
Agricultural Branch,
Harrow.

## TABLE I

## MONTHLY AVERAGES OF ACCUMULATED TEMPERATURE ABOVE 42°F. (in day degrees)

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cockle Park | 27 | 33 | 73 | 126 | 231 | 390 | 508 | 477 | 358 | 207 | 82 | 41 | 2553 |
| Newton Rigg | 28 | 31 | 77 | 142 | 276 | 417 | 512 | 503 | 358 | 203 | 79 | 41 | 2667 |
| Houghall | 37 | 46 | 95 | 161 | 273 | 428 | 548 | 528 | 395 | 232 | 97 | 49 | 2889 |
| York | 47 | 50 | 106 | 185 | 328 | 476 | 640 | 613 | 464 | 278 | 97 | 55 | 3339 |
| Stonyhurst | 29 | 22 | 61 | 143 | 303 | 435 | 574 | 543 | 414 | 237 | 84 | 48 | 2893 |
| Southport | 52 | 41 | 94 | 176 | 355 | 462 | 583 | 570 | 451 | 286 | 128 | 65 | 3263 |
| Sealand | 69 | 59 | 115 | 199 | 322 | 474 | 601 | 589 | 452 | 295 | 135 | 84 | 3394 |
| Cranwell | 42 | 46 | 106 | 187 | 304 | 471 | 607 | 587 | 453 | 267 | 99 | 45 | 3214 |
| Sutton Bonington | 45 | 50 | 110 | 193 | 329 | 483 | 610 | 587 | 441 | 252 | 113 | 60 | 3273 |
| Newport (Salop) | 43 | 46 | 101 | 177 | 311 | 455 | 561 | 555 | 414 | 238 | 107 | 55 | 3063 |
| Worcester | 58 | 63 | 124 | 217 | 361 | 515 | 621 | 615 | 458 | 272 | 128 | 70 | 3502 |
| Sprowston | 42 | 46 | 103 | 184 | 327 | 489 | 622 | 616 | 483 | 287 | 120 | 55 | 3374 |
| Thetford | 41 | 46 | 103 | 183 | 328 | 465 | 591 | 577 | 450 | 250 | 104 | 50 | 3188 |
| Woburn | 43 | 47 | 106 | 189 | 329 | 477 | 604 | 594 | 443 | 251 | 109 | 56 | 3248 |
| Rothamsted | 36 | 40 | 98 | 177 | 319 | 474 | 593 | 589 | 441 | 246 | 100 | 47 | 3160 |
| Long Sutton | 42 | 48 | 115 | 199 | 347 | 501 | 611 | 612 | 463 | 271 | 118 | 58 | 3385 |
| Wisley | 55 | 59 | 131 | 224 | 378 | 531 | 643 | 639 | 485 | 290 | 134 | 69 | 3638 |
| East Malling | 52 | 54 | 113 | 208 | 345 | 507 | 618 | 613 | 464 | 277 | 122 | 65 | 3438 |
| Wye | 45 | 48 | 110 | 204 | 350 | 501 | 616 | 622 | 474 | 289 | 124 | 61 | 3444 |
| Long Ashton | 65 | 62 | 127 | 213 | 353 | 501 | 600 | 609 | 468 | 288 | 144 | 81 | 3511 |
| Cannington | 79 | 77 | 137 | 223 | 359 | 520 | 621 | 638 | 496 | 316 | 163 | 95 | 3724 |
| Newton Abbot | 74 | 70 | 127 | 207 | 346 | 491 | 589 | 612 | 476 | 311 | 162 | 90 | 3555 |
| Ellbridge | 84 | 73 | 135 | 214 | 348 | 488 | 579 | 601 | 472 | 315 | 172 | 101 | 3582 |
| Gulval | 119 | 102 | 158 | 230 | 351 | 489 | 578 | 609 | 495 | 358 | 222 | 143 | 3854 |
| Aber | 83 | 73 | 132 | 198 | 326 | 462 | 562 | 573 | 467 | 314 | 177 | 111 | 3478 |
| Llety-evan-hen | 28 | 24 | 68 | 119 | 248 | 371 | 450 | 483 | 362 | 210 | 94 | 42 | 2499 |
| Aberystwyth | 47 | 41 | 96 | 155 | 295 | 422 | 505 | 538 | 423 | 266 | 135 | 73 | 2996 |
| Parkend | 48 | 50 | 105 | 184 | 318 | 461 | 557 | 553 | 418 | 247 | 108 | 62 | 3111 |

## TABLE II

### MONTHLY AVERAGES OF ACCUMULATED TEMPERATURE BELOW 42°F. (in day degrees)

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cockle Park | 187 | 151 | 114 | 51 | 21 | 2 | 0 | 0 | 4 | 22 | 66 | 124 | 742 |
| Newton Rigg | 201 | 170 | 119 | 53 | 24 | 4 | 0 | 1 | 8 | 34 | 84 | 153 | 851 |
| Houghall | 207 | 152 | 113 | 49 | 27 | 5 | 1 | 2 | 11 | 32 | 73 | 143 | 815 |
| York | 199 | 133 | 70 | 29 | 10 | 0 | 0 | 0 | 2 | 12 | 48 | 114 | 617 |
| Stonyhurst | 192 | 171 | 78 | 31 | 10 | 0 | 0 | 0 | 2 | 13 | 60 | 128 | 685 |
| Southport | 168 | 130 | 69 | 29 | 9 | 0 | 0 | 0 | 2 | 12 | 44 | 102 | 565 |
| Sealand | 159 | 123 | 67 | 32 | 15 | 3 | 0 | 0 | 3 | 17 | 43 | 99 | 561 |
| Cranwell | 197 | 153 | 86 | 38 | 13 | 0 | 0 | 0 | 2 | 13 | 58 | 141 | 701 |
| Sutton Bonington | 199 | 147 | 103 | 38 | 17 | 3 | 0 | 1 | 5 | 25 | 62 | 134 | 734 |
| Newport (Salop) | 194 | 145 | 105 | 45 | 21 | 3 | 1 | 1 | 8 | 33 | 65 | 135 | 756 |
| Worcester | 168 | 129 | 93 | 36 | 17 | 2 | 0 | 1 | 7 | 29 | 61 | 129 | 672 |
| Sprowston | 169 | 141 | 97 | 32 | 15 | 2 | 0 | 1 | 2 | 17 | 46 | 121 | 643 |
| Thetford | 214 | 173 | 130 | 60 | 32 | 7 | 2 | 4 | 10 | 36 | 77 | 172 | 917 |
| Woburn | 193 | 155 | 106 | 42 | 17 | 2 | 0 | 1 | 5 | 28 | 64 | 147 | 760 |
| Rothamsted | 199 | 158 | 106 | 38 | 15 | 1 | 0 | 0 | 2 | 21 | 65 | 151 | 756 |
| Long Sutton | 178 | 151 | 98 | 39 | 16 | 1 | 0 | 0 | 4 | 22 | 59 | 137 | 705 |
| Wisley | 160 | 132 | 85 | 30 | 13 | 1 | 0 | 0 | 4 | 23 | 54 | 129 | 631 |
| East Malling | 174 | 142 | 95 | 34 | 17 | 2 | 0 | 1 | 5 | 29 | 63 | 133 | 695 |
| Wye | 168 | 136 | 89 | 30 | 13 | 1 | 0 | 1 | 3 | 21 | 52 | 134 | 648 |
| Long Ashton | 140 | 114 | 75 | 26 | 12 | 1 | 0 | 0 | 3 | 18 | 46 | 106 | 541 |
| Cannington | 117 | 101 | 66 | 21 | 9 | 0 | 0 | 0 | 2 | 11 | 34 | 89 | 450 |
| Newton Abbot | 101 | 95 | 57 | 21 | 9 | 0 | 0 | 0 | 1 | 7 | 28 | 78 | 397 |
| Ellbridge | 91 | 89 | 54 | 20 | 10 | 1 | 0 | 0 | 3 | 11 | 32 | 76 | 387 |
| Gulval | 50 | 52 | 29 | 11 | 4 | 0 | 0 | 0 | 0 | 2 | 10 | 37 | 195 |
| Aber | 83 | 75 | 48 | 15 | 5 | 0 | 0 | 0 | 1 | 4 | 15 | 47 | 293 |
| Llety-evan-hen | 161 | 150 | 97 | 40 | 14 | 1 | 0 | 0 | 1 | 11 | 43 | 105 | 623 |
| Aberystwyth | 119 | 110 | 68 | 25 | 9 | 0 | 0 | 0 | 1 | 7 | 27 | 78 | 444 |
| Parkend | 175 | 128 | 106 | 42 | 20 | 3 | 0 | 1 | 7 | 27 | 64 | 135 | 708 |

TABLE III

SEASONAL AVERAGES OF ACCUMULATED TEMPERATURE

| | ABOVE 42°F. | | | | | BELOW 42°F. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Spring Mar-May | Summer June-Aug | Autumn Sep-Nov | Winter Dec-Feb | Year | Spring Mar-May | Summer Jun-Aug | Autumn Sep-Nov | Winter Dec-Feb | Year |
| Cockle Park | 430 | 1375 | 647 | 101 | 2553 | 186 | 2 | 92 | 462 | 742 |
| Newton Rigg | 495 | 1432 | 640 | 100 | 2667 | 196 | 5 | 126 | 524 | 851 |
| Houghall | 529 | 1504 | 724 | 132 | 2889 | 189 | 8 | 116 | 502 | 815 |
| York | 619 | 1729 | 839 | 152 | 3339 | 109 | 0 | 62 | 446 | 617 |
| Stonyhurst | 507 | 1552 | 735 | 99 | 2893 | 119 | 0 | 75 | 491 | 685 |
| Southport | 625 | 1615 | 865 | 158 | 3263 | 107 | 0 | 58 | 400 | 565 |
| Sealand | 636 | 1664 | 882 | 212 | 3394 | 114 | 3 | 63 | 381 | 561 |
| Cranwell | 597 | 1665 | 819 | 133 | 3214 | 137 | 0 | 73 | 491 | 701 |
| Sutton Bonington | 632 | 1680 | 806 | 155 | 3273 | 158 | 4 | 92 | 480 | 734 |
| Newport (Salop) | 589 | 1571 | 759 | 144 | 3063 | 171 | 5 | 106 | 474 | 756 |
| Worcester | 702 | 1751 | 858 | 191 | 3502 | 146 | 3 | 97 | 426 | 672 |
| Sprowston | 614 | 1727 | 890 | 143 | 3374 | 144 | 3 | 65 | 431 | 643 |
| Thetford | 614 | 1633 | 804 | 137 | 3188 | 222 | 13 | 123 | 559 | 917 |
| Woburn | 624 | 1675 | 803 | 146 | 3248 | 165 | 3 | 97 | 495 | 760 |
| Rothamsted | 594 | 1656 | 787 | 123 | 3160 | 159 | 1 | 88 | 508 | 756 |
| Long Sutton | 661 | 1724 | 852 | 148 | 3385 | 153 | 1 | 85 | 466 | 705 |
| Wisley | 733 | 1813 | 909 | 183 | 3638 | 128 | 1 | 81 | 421 | 631 |
| East Malling | 666 | 1738 | 863 | 171 | 3438 | 146 | 3 | 97 | 449 | 695 |
| Wye | 664 | 1739 | 887 | 154 | 3444 | 132 | 2 | 76 | 438 | 648 |
| Long Ashton | 693 | 1710 | 900 | 208 | 3511 | 113 | 1 | 67 | 360 | 541 |
| Cannington | 719 | 1779 | 975 | 251 | 3724 | 96 | 0 | 47 | 307 | 450 |
| Newton Abbot | 680 | 1692 | 949 | 234 | 3555 | 87 | 0 | 36 | 274 | 397 |
| Ellbridge | 697 | 1668 | 959 | 258 | 3582 | 84 | 1 | 46 | 256 | 387 |
| Gulval | 739 | 1676 | 1075 | 364 | 3854 | 44 | 0 | 12 | 139 | 195 |
| Aber | 656 | 1597 | 958 | 267 | 3478 | 68 | 0 | 20 | 205 | 293 |
| Llety-evan-hen | 435 | 1304 | 666 | 94 | 2499 | 151 | 1 | 55 | 416 | 623 |
| Aberystwyth | 546 | 1465 | 824 | 161 | 2996 | 102 | 0 | 35 | 307 | 444 |
| Parkend | 607 | 1571 | 773 | 160 | 3111 | 168 | 4 | 98 | 438 | 708 |

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A.M. Form 1013.

**FIG. 1.**

FIG. 2.

# Variations about Seasonal Means of Accumulated Temperature at Gulval and Rothamsted (1931-48)

## ABOVE 42°F

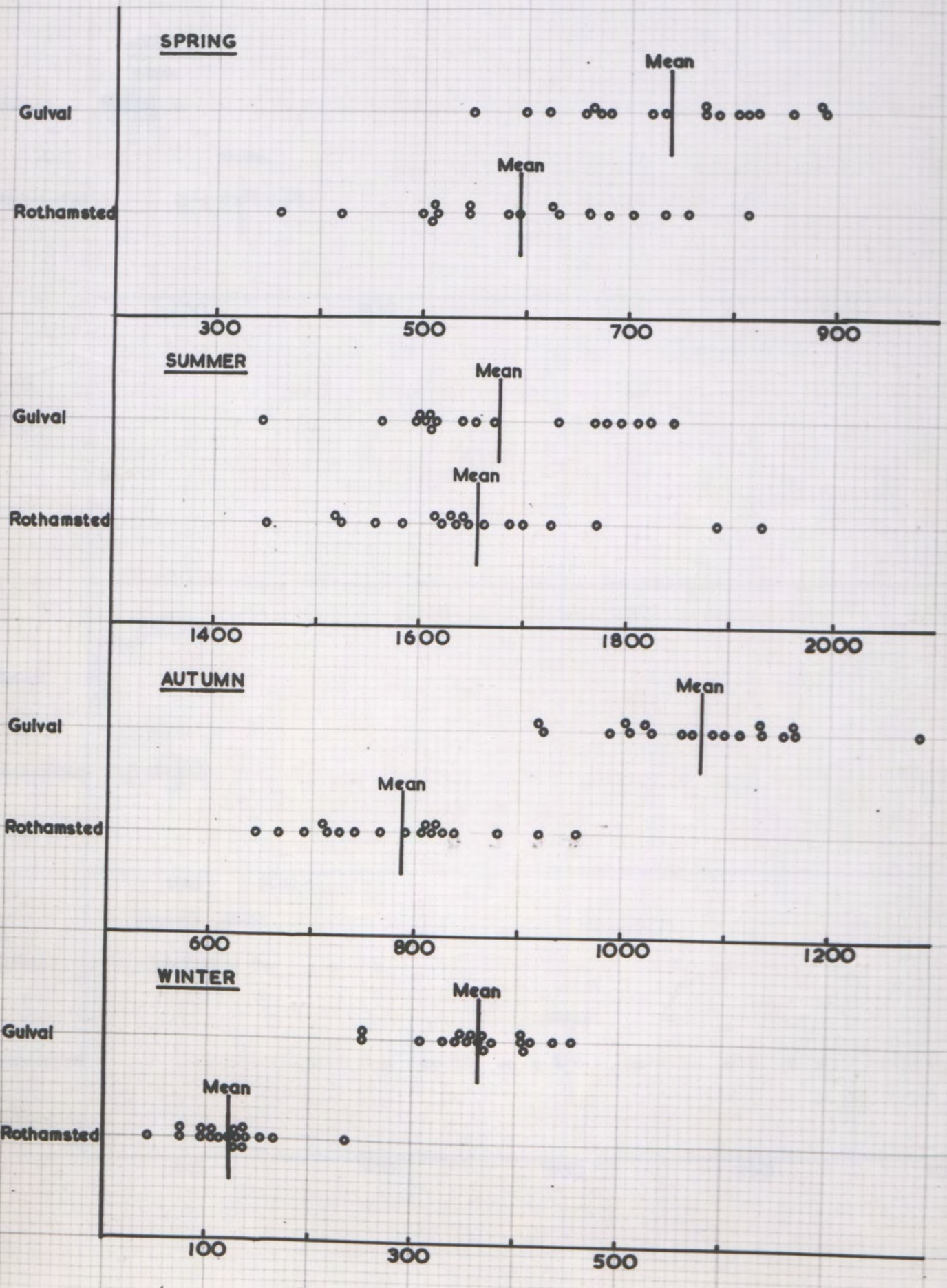

FIG. 3.

# Variations about Seasonal Means of Accumulated Temperature at Gulval and Rothamsted (1931-48)

## BELOW 42°F

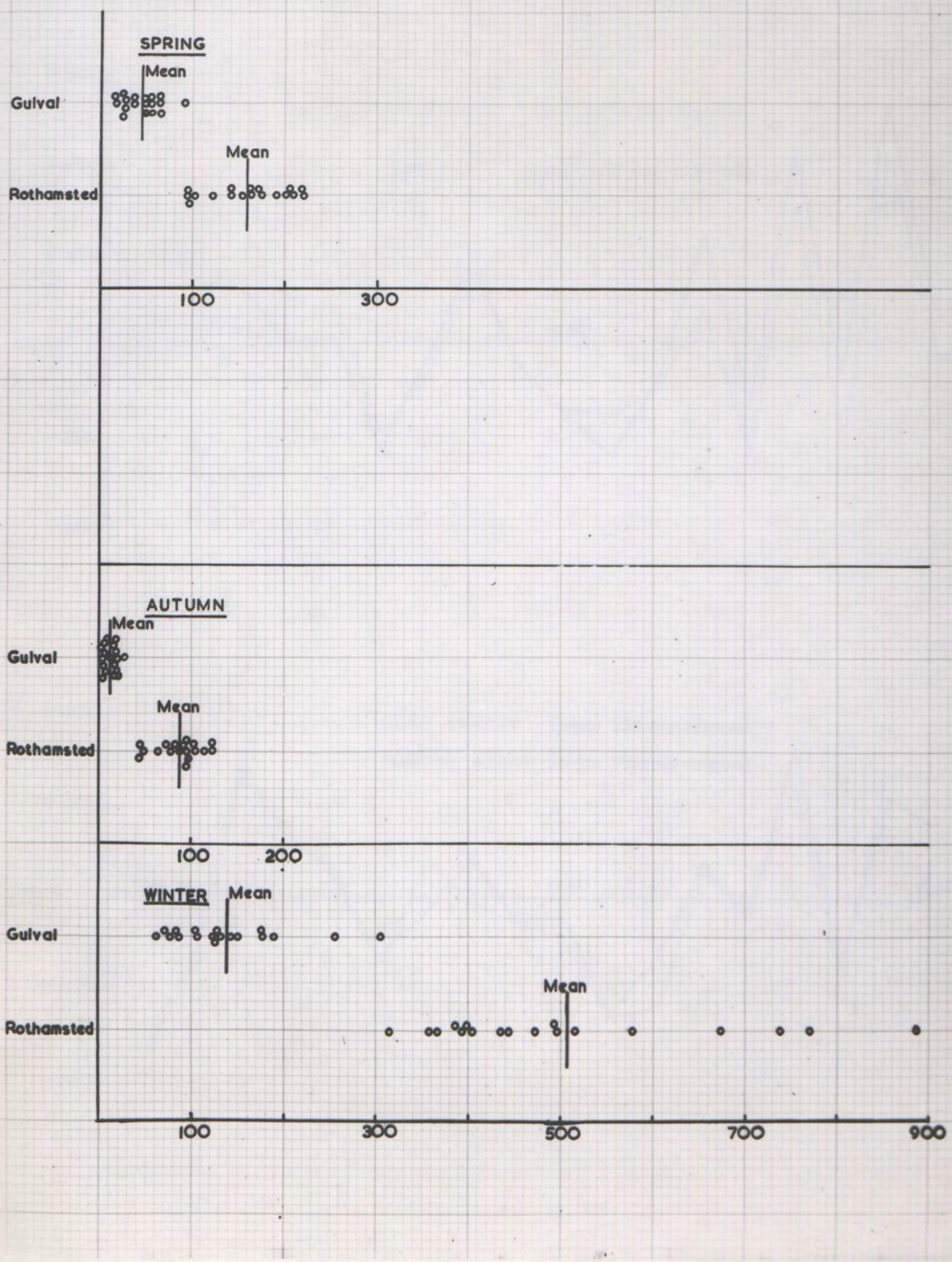

FIG. 4.

## Deviations from the Annual Means of Accumulated Temperature (above 42°F) at two stations in E. Anglia and S. W. England (1931-48)